

a relatively pure limestone, easily enough recognized as a distinct group of minor units by its lithology and fossils. In the middle belts of the Valley, and in Pennsylvania also in the country to the southeast of the Valley proper, the Trenton, as determined by its fossils, is represented by the lower part of the Martinsburg shale, as shown in sections 3 to 5, Figure 1.

Formations of Richmond age.—If identifications of fossils and correlations of formations are correct, one of the most noteworthy examples of facies differences is found in the Medina group of the New York classification and its equivalents elsewhere. In Pennsylvania the Juniata formation is non-marine red shale and red sandstone. In southwestern Virginia it is red shale with layers of impure limestone carrying marine fossils, the Sequatchie formation. On the escarpment south of Lake Ontario its equivalent is the red Queenston shale. Going from Queenston through Ontario, Canada, to the northern end of Lake Huron and thence southward into southeastern Indiana, this non-marine red shale of Pennsylvania and New York can be traced step by step into the highly fossiliferous limestone of the Richmond group of southern Indiana and southwestern Ohio. From Indiana and southwestern Ohio, the Richmond, still fossiliferous, can be traced into northwestern Alabama and unmistakably identified in Sequatchie and Big Wills Valleys in Tennessee and Alabama, where, however, red color begins to appear in the argillaceous limestone. From Big Wills Valley it can be traced far into Tennessee and probably into southwestern Virginia where, as noted above, the unit is red shale with layers of impure limestone. The upper part of the old Medina group, now named Albion sandstone, so fully displayed in the Niagara gorge and containing in its lower part a few marine fossils, is almost certainly the same as the non-marine Tuscarora quartzite of Pennsylvania and the Clinch sandstone of Virginia. The stratigraphic position of the Albion, Tuscarora, and Clinch is identical—between the Queenston-Juniata-Sequatchie below and the Clinton above. Northwestward through Ontario the Albion, in part at least, is the same as the fossiliferous, partly limestone Cataract formation, and this in turn is correlated through its fossils with the fossiliferous marine Brassfield limestone of Ohio and Kentucky. The Brassfield through its fossils is identified by Ulrich with part of the iron ore-bearing Rockwood formation at Rockwood, Tennessee, and at Jasper, Sequatchie Valley, Tennessee, and with the part of the Red Mountain formation of Alabama below the "Big Seam" of iron ore. The part of the Red Mountain formation overlying and including the "Big Seam"

is of Clinton age. At Cumberland Gap, Virginia-Tennessee, the Brassfield fauna is found in beds that are limy at the top and gritty at the bottom and which, like the Clinch sandstone of Virginia and the Tuscarora quartzite of Pennsylvania, lie between the Clinton above and the Sequatchie or Juniata below. There seems no considerable doubt that the Albion, Cataract, Brassfield, Clinch, and Tuscarora are all different facies and names for essentially one time unit.

Mississippian formation.—As a last example of facies change, I will mention that which takes place in the Mississippian formations of southwestern Virginia. At Cumberland Gap the Keokuk and St. Louis are very thinly represented and the intervening Warsaw is absent. All the other Mississippian formations at Cumberland Gap are relatively thin, aggregating barely 1000 feet. In the trough south-east of Clinch Mountain (Figure 1, section 3), the Keokuk is absent, but the Warsaw and St. Louis are well represented and the total thickness of the Mississippian is around 6000 feet. It is one of the thickest Mississippian sections known. Except for the Price and Pennington formations, which are elastic in both regions, there is a marked difference in composition of the formations in the two regions. The change in thickness and composition is particularly striking in the Ste. Genevieve and Gasper formations. At Cumberland Gap they are composed of thick-bedded oolitic limestone of high purity and their combined thickness is about 200 feet. Southeast of Clinch Mountain, on the other hand, these formations are predominantly highly argillaceous, thinly laminated limestone which weathers to a soft material much like a shale and their thickness is over 2300 feet as against 200 feet at Cumberland Gap. This difference is probably due to the proximity of the southeastern area to the sources of the clastic sediment which is mixed with the calcareous constituents of the formation.

CONCLUSIONS

The most important conclusion to be drawn from the distribution of the various formational units of the Appalachian Valley is that the Appalachian Geosyncline and a great area to the west were in a state of intermittent warping. At a given time one part was above water and another part below. At a later time the conditions were reversed. Sometimes, as in Nittany and Lowville times, submergence was certainly widespread if not universal; at other times, as in the time when the Tellico sandstone was laid down in the Knoxville region, emergence prevailed. Through all of upper Chazy ("Blount"), time the dis-